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Bioproductivity in the Southern Ocean since the last Interglacial – new high-resolution biogenic opal flux records from the Scotia Sea

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The Southern Ocean plays an important role in transferring CO_2 via wind-induced upwelling from the deep sea to the atmosphere. It is therefore one of the key areas to study climate change. Bioproductivity in the Southern Ocean is mostly influenced by the extent of sea ice, upwelling of cold nutrient- and silica-rich water, and the availability of light. Biogenic opal (BSi) is a significant nutrient in the Southern Ocean, and according to recent investigations only marginally affected by preservation changes. It can therefore be used as bioproductivity proxy.

Here we present several methods to determine BSi, discuss them and put the results into context with respect to regional bioproductivity changes in Southern Ocean during the last glacial cycle. We studied deep-sea sediment core sites MD07-3133 and MD07-3134 from the central Scotia Sea with extraordinary high sedimentation rates of up to 2.1 to 1.2 m/kyr, respectively covering the last 92.5 kyr. BSi leaching according to Müller & Schneider (1993) is very time-consuming and expensive, so we measured only 253 samples from large-amplitude variation core sections. In addition, we determined BSi using non-destructive measurements of sediment colour b*, wet-bulk density, and Ti/Si count ratios. Furthermore, we provide the first attempts to estimate BSi in marine sediment using Fourier transform infrared spectroscopy (FTIRS), a cost-efficient method, which requires only 11 mg of sediment. All estimation methods capture the main BSi trends, however FTIRS seems to be the most promising one.

In the central Scotia Sea, south of the modern Antarctic Polar Front, the BSi flux reflects a relatively complicated glacial-to-interglacial pattern with large-amplitude, millennial-scale fluctuations in bioproductivity. During Antarctic Isotopic Maxima, BSi fluxes were generally increased. Lowest bioproductivity occur at the Last Glacial Maximum, while upwelling of mid-depth water was reduced, atmospheric CO_2 low, and sea-ice cover intensified. Around 17 ka BSi flux rose abruptly, corresponding to decreasing seasonal sea-ice cover and rising atmospheric CO_2 concentration. Our investigations show that BSi flux in the Central Scotia Sea reflects bioproductivity changes. Furthermore it is correlated to atmospheric CO_2 variations and sea-ice cover fluctuations. Distribution of sea ice may be the reason for pronounced regional differences of bioproductivity in the Southern Ocean.